

Theme 2: Modeling, Data Assimilation, and Advanced Computing



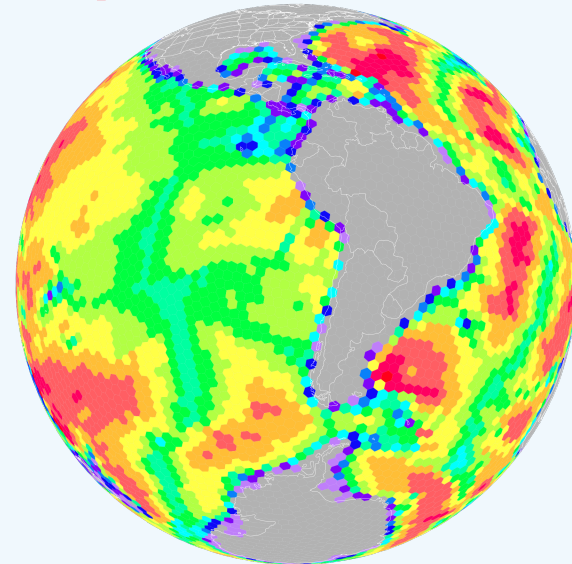
Zoltan Toth

Summary and Way Forward



Outline

- Review of scientific highlights from **oral presentations**
 - Links with strategic plans
 - *Societal impact of research*
- Preview of **poster presentations**
 - Selected applications
- **Future outlook**
 - Major initiatives in response to societal/scientific challenges



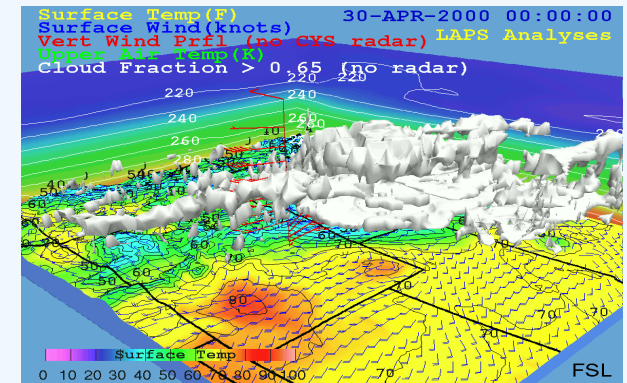
NOAA Strategic Plan 2009-2014 – State of the Art Research

- *Long-term - Recognizes emerging issues & opportunities*
- *Short-term - Increases the effectiveness of existing activities*



Data Assimilation

- Pioneering ESRL research contributions
 - Fine resolution analyses (1-10 km scale) moving toward Warn-On-Forecast applications
 - Inclusion of new data types, e.g. surface and moisture-related observations, GPS-Met
 - Frequent updates in support of aviation, e.g. improved situational awareness
 - Case-specific ensemble-based background error covariance, e.g. Hybrid EnKF and 3 or 4DVAR
- Wide range of NOAA, national & international users & sponsors, i.e. *NCEP, WFOs, USAF, Army operations using (LAPS)*
- Coordinated planning with NOAA & external partners



- **NOAA 5-yr Research Plan Performance Objective & Research Milestone**
 - *Improve predictability of the onset, duration, and impact of hazardous and high-impact severe weather and water events* - Determine viability of different data assimilation approaches

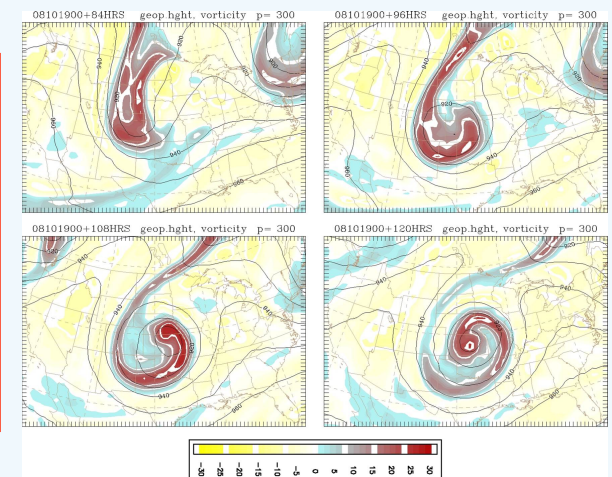


Numerical Modeling

- Main thrust - highest accuracy in transport processes
 - Very fine resolution regional and global model development for aviation, hurricane, pollutant transport applications
 - Optimal choice of horizontal and vertical discretization, e.g. icosahedral-hexagonal grid or quasi-Lagrangian vertical coordinate
 - Coupling with ocean and air chemistry allows Earth system approach over timescales from minutes to months
- Weather, climate, and emerging Earth system modeling applications
Impact on NCEP operations with (RUC)

- **NOAA 5-yr Research Plan Objective & Research Milestone**

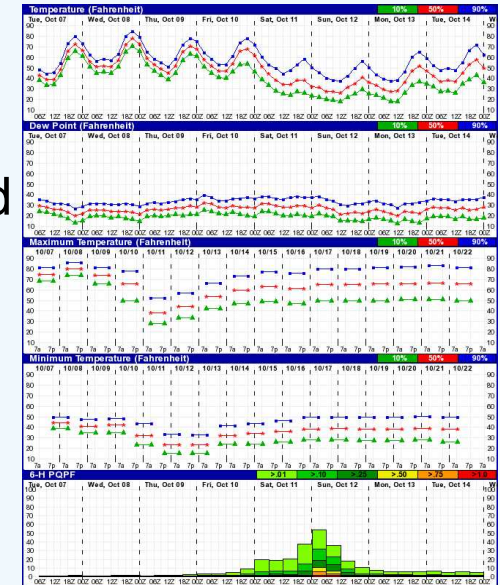
- **Increase lead time & accuracy for weather & water warnings & forecasts - Provide integrated environmental information and services in collaboration with NCEP, NCAR & GFDL**





Forecast Uncertainty

- New ensemble & decision-support methods
 - Fine resolution ensemble systems for aviation and hydrological applications
 - Statistical post-processing techniques for reliable and precise probabilistic forecasts
 - Comprehensive ensemble forecast database for use by professional decision-support systems
 - Ensemble forecast display and interrogation tools for NWS and broader user community
- In response to societal needs – *Impact - Decision Support system*
- In collaboration with NWS Forecast Uncertainty program and AMS Ad Hoc Committee on Uncertainty in Forecasting



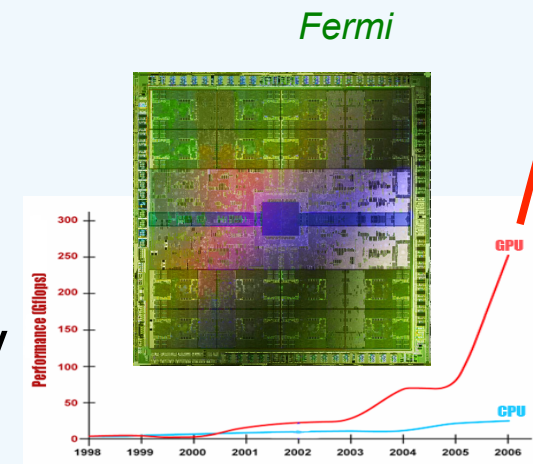
- **NOAA 5-yr Research Plan Objectives & Research Milestones**
 - *Increase application and accessibility of weather and water information* - Provide decision-support services based upon probabilistic model guidance
 - *Reduce uncertainty associated with weather & water decision tools* - ...better ensemble and statistical post-processing techniques





Advanced Computing

- Boulder HPC Facility vital to ESRL research & development
 - Supports numerical modeling and data assimilation work - portability, performance, interoperability
- Explores new & faster technologies
 - Massively Parallel Processor (MPP, 1992)
 - Linux Clusters (2000)
 - GPUs (2008) - Next generation super-computers
- Benefits ESRL, NOAA & wider community
IT development – *Impact - Use of GPU technology (34 times faster)*
- Developed as integral part of NOAA HPC infrastructure



- *NOAA 5-yr Research Plan Objective*

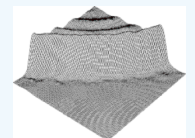
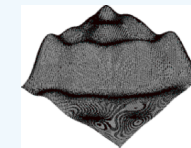
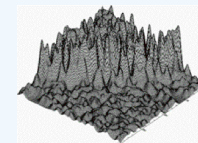
- *Increase development, application, and transition of advanced science and technology to operations and services*



Preview of Posters

- Data assimilation

- Multiscale variational approach for optimal use of data with varying scales
 - Yuanfu Xie – STMAS
- Ensemble-based scheme as an alternative to variational approaches
 - Jeff Whitaker – EnKF
- Hourly updating analysis/forecast system for aviation
 - Ming Hu – RR/HRRR
- Improved use of GOES moisture information
 - Dan Birkenheuer – Via GPS data



- High performance computing

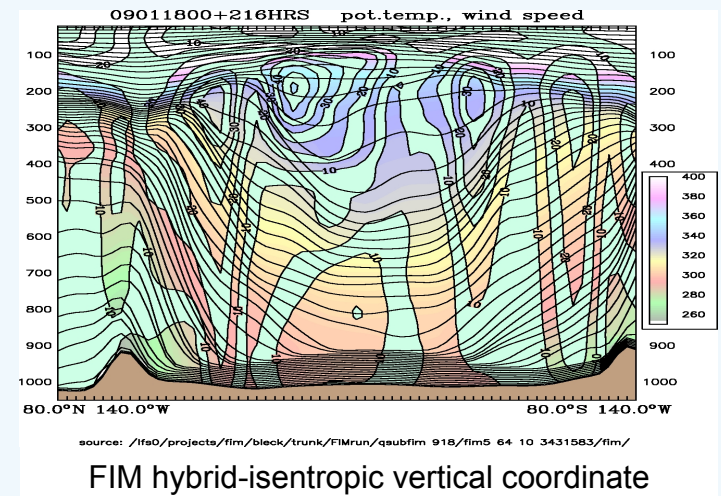
- HPC developments in support of numerical modeling activities
 - Craig Tierney
- Graphics Processing Units for enabling science
 - Jacques Middlecoff – NIM application

*NOAA Strategic Plan 2009-2014 – working with partners
...widespread computing and model accessibility will ... accelerate our ability
to understand, describe, assess and predict the environment*



Preview of Posters - 2

- Numerical modeling
 - Coupled global atmosphere-ocean-chemistry model-pollutant transport etc.
 - Georg Grell – FIM-Chem
 - Physics parameterization research for multiscale applications
 - Jian-Wen Bao – FIM model development
 - Vertical coordinates & transport
 - Rainer Bleck – FIM application
 - Nonhydrostatic modeling
 - Jin Lee – NIM
 - Fire / chemical modeling
 - Steven Peckham – HRRR
- Forecast uncertainty
 - Probabilistic products for convective processes
 - Curtis Alexander – Built on RUC/HRRR infrastructure



NOAA Annual Guidance Memo 2009 – Core Competencies to Strengthen improvements in forecasts ... for ... high-impact events ... create more effective decision support capabilities and to better convey forecast risk and uncertainty



Emerging Needs - 1

- Societal challenge

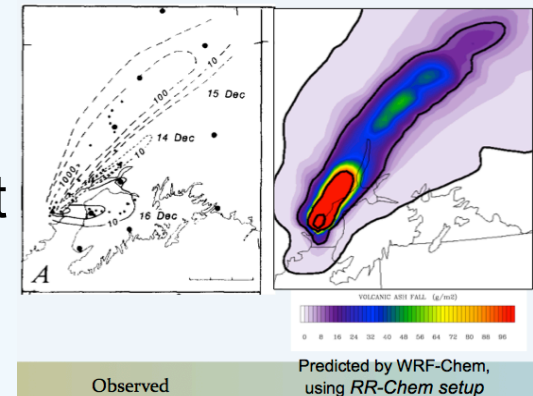
- Seamless forecast system from minutes to months

- Scientific challenge

- Fully coupled Earth system model development

- ESRL response

- Ocean, biosphere, cryosphere, chemical model development for weather / global scales – **Complement GFDL climate modeling**
 - 2-way coupled regional models for high impact event forecasting
 - In collaboration with NSSL, AOML, ARL



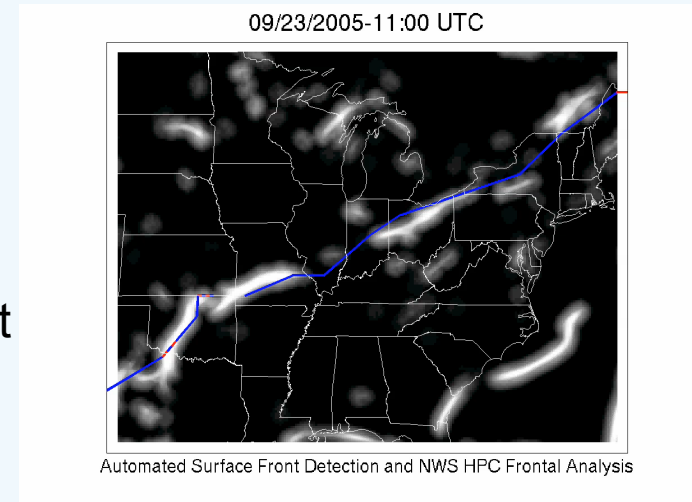
- **NOAA 20-yr Research Vision**

Holistic Earth system models is a major goal of NOAA research in the next 20 years



Emerging Needs - 2

- Societal challenges
 - Air traffic congestion due to convective events
 - Inadequate lead time for severe weather warnings
- Scientific challenge
 - Resolve convective initiation for Warn-On-Forecast
- ESRL response
 - Innovative research into
 - Cloud-scale & boundary layer modeling – [Partnering with NSSL](#)
 - New observing systems and techniques
 - Non-Gaussian data assimilation
 - Potential applications
 - NextGen in aviation and improved severe weather warnings



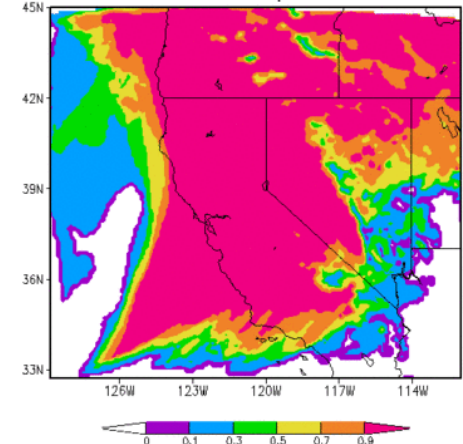
- **NOAA 20-yr Research Vision**
- **Tornado track forecasts at sub-county level with one hour or more lead time**



Emerging Needs - 3

- Societal challenge
 - Forecast uncertainty information needed for decision-sup
- Scientific challenge
 - Reliable and precise ensemble / probabilistic forecasts
- ESRL response
 - Multiscale coupled ensemble system development
 - EnKF, stochastic modeling
 - New statistical post-processing methods
 - Communication of forecast uncertainty
 - Applications
 - Ensemble Testbed at Developmental Testbed Center

initial 2010020418, 24 h fcst, 9 km, 9 mem, HMT-West
0.01 inch prob.



NOAA 20-yr Research Vision

Decision support tools to affect transit time, delivery reliability, efficiency, cost of goods transported, and the health of the environment



Summary – Way Forward

- ESRL has been pioneering new observing / modeling / computer architectures for NWP
 - From hours to days, mostly regional scales
 - Major contributions to NWS/NCEP and other user groups
 - In strong partnership with other NOAA Labs, NCAR, NASA, universities
- Opportunities emerging at intersection of science & technology
- ESRL's vision for continued high quality & socially relevant research
 - **Coupled** atmosphere-land-ocean-chemistry **global** modeling
 - Minutes to **months** timescale
 - Innovative use of **emerging observing & computing technologies**
 - In **strong collaboration** with partners and users

- **NOAA 20-yr Research Vision**

- **Advanced real-time observational systems coupled with electronic charts, navigation systems, & forecast models**